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STUDIES ON INFLUENCE OF METEOROLOGICAL FACTORS ON COSMIC RAY INTENSITY

[Comment: This report contains three articles on the influence of meteorological factors on cosmic ray intensity. The articles were submitted by the Yakutsk Affiliate, Academy of Sciences USSR, on 19 January 1954 and published in the Zhurnal Eksperimental'noy i Teoreticheskoy Fiziki, Vol 28, No 5, Moscow, May 1955.

Numbers in parentheses refer to authors' bibliographies. Figures and bibliographies are appended at the end of each article.]

INFLUENCE OF MOON-TIDE FLUCTUATIONS OF ATMOSPHERE ON INTENSITY OF HARD COMPONENT OF COSMIC RAYS

A. I. Kuz'min
G. V. Skripin

An examination of the influence of moon-tide fluctuations of the atmosphere on the intensity of the hard component of cosmic rays δI is of interest for the study of the nature of semidiurnal variations in the intensity of cosmic rays (1) as well as for the study of the nature of daily fluctuations in the temperature of the upper atmosphere. (2) In connection with the fact that the period of the main moon-tide fluctuation of the atmosphere is equal to half of the lunar day (3), we can expect the manifestation of an influence of these fluctuations in regular semidiurnal variations on the intensity of cosmic rays. However, regular semidiurnal variations can be masked by statistical fluctuations of the particles of cosmic rays. For this reason the investigation of the moon-tide component can be conducted only by the statistical method.

If the observed semidiurnal wave in δI is the sum of two waves: the wave S with period T_S = 12 hours and the wave M with period T_M = 12 hours, 25 minutes, 14 seconds (half of the lunar day), and if at the moment of time, $t_o = 0$, the phase displacement of the waves S and M is equal to $\Delta\varphi_o$ degrees, than after the period T_S the phase displacement increases by $360\,(T_M - T_S)/T_S$ degrees. Consequently, after a certain number n of periods T_S the increase in the initial phase difference will reach 360°. From this, one gets $n = T_S/(T_M - T_S)$ = 28.6 periods T_S or 14.3 solar days. Thus waves S and M have one and the same phase displacement $\Delta\varphi_i$ (i = 0, 1, 2, 3, ...) at the times t_i, $t_i + n$, $t_i + 2n$, ..., $t_i + kn$. Therefore, averaging the semidiurnal course of δI with respect to the indicated moments of time, one can determine the mean parameters of this course for a definite phase displacement $\Delta\varphi_i$ of waves S and M. Having determined the average values of the parameters of the semidiurnal wave δI for various initial times of averging t_o, t_1, t_2, .. (in the interval of 14.3 solar days), one can construct a curve of the dependence of the amplitude of the semidiurnal wave δI upon the phase displacement $\Delta\varphi_i$ of waves S and M. The course of this curve will show the effect of the moon-tide component M in the semidiurnal variations of δI.

In accordance with this scheme, experimental measurements of δI, obtained with an accuracy up to several tenths of a percent for one hour's observations, were conducted. The parameters of the semidiurnal wave were calculated for the following phase displacements: $\Delta\varphi_o^o$, $(\Delta\varphi_o + 100)^o$, $(\Delta\varphi_o + 175)^o$, and $(\Delta\varphi_o + 275)^o$. For each phase displacement 70 solar days were chosen. The results obtained are presented in the appended figure. It can be seen that the amplitude of the semidiurnal

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wave δI depends strongly upon the phase displacements of waves S and M, i.e., upon the choice of the initial time of averaging t_i, and falls into a regular sinusoidal curve with a period of 14.3 days. Such dependence can exist only when a component with a period of 12 hours, 25 minutes, and 14 seconds is present in the semidiurnal variations of δI.

The reality of wave M is confirmed by a table in which are indicated the parameters of the semidiurnal wave δI, found from continuous hourly data over 2-month periods.

	Amplitude (%)	Time of Maximum (hr:min)
Mar - Apr	0.069 ± 0.003	1:40
May - Jun	0.078 ± 0.003	2:40
Jul - Aug	0.036 ± 0.003	1:30
Sep - Oct	0.070 ± 0.003	2:40
Nov - Dec	0.063 ± 0.003	1:16

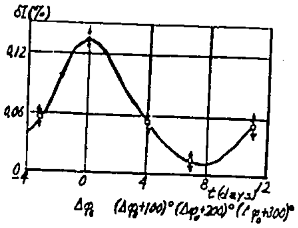
From the table it can be seen that the fluctuations of the wave amplitude on the average do not exceed 0.003%, whereas in a summation after 14.3 days, with respect to the same number of days, they reach 0.04%. Assuming that the maximum of the curve corresponds to coincidence of the phases of waves S and M, and the minimum to a phase displacement between them of 180°, and by using the data of the table, we find the average amplitude of wave M equals 0.05%. Knowing the parameters of waves S and M, it is possible to calculate the phase of the resultant wave for each of the initial times of averaging. The calculation showed that the phase of the resultant curve must fluctuate within the limits of 3 hours (90°). In fact, the phases of the resultant curve which correspond to the initial times of averaging, shown in the figure, fall practically within this interval, and the course of the phase variation corresponds to the representations adopted in the calculation.

The amplitude and phase of M, calculated by continuous summation of the data of δI for 1951-1952 with respect to the time of the main lunar wave with a period of 24 hours, 50 minutes and 14 seconds, coincided with the characteristics indicated above.

The moon-tide wave in the atmosphere, established in Bartels (4) and Chapman (5), has an amplitude within the variation of terrestrial pressure of approximately 0.08 mb. A variation of barometric pressure with such an amplitude can account for 20% of the amplitude of wave M in the intensity of cosmic rays. Therefore, to explain the remaining 0.04% of the amplitude of M we must assume that the tide fluctuations of the atmosphere are manifested mainly in a redistribution of an air mass along the vertical. Such shifts of air masses along the vertical must lead to semidiurnal fluctuations of temperature in the upper layers, which is actually the case as Ye. S. Selezneva (2) showed in 1945. An analysis (2) of considerable statistical material showed that beginning at 3 km diurnal fluctuations have several maxima. The fundamental maximum characterizes the diurnal fluctuations, and the other maxima characterize the semidiurnal fluctuations, while the amplitudes of the semidiurnal fluctuations increase with altitude.

We feel that besides the factors indicated by Selezneva (2) to explain similar maxima in the diurnal course of the temperature in the troposphere, it is apparent that tide fluctuations deserve a significant place.

In conclusion we thank Prof Ye. L. Feynberg for his many valuable comments.



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VARIATIONS IN GLOBAL INTENSITY OF HARD COMPONENT OF COSMIC RAYS DURING PASSAGE OF AIR MASS FRONTS

D. D. Krasil'nikov

An examination of variations in the intensity of cosmic rays for definite typical cases of change of state of the atmosphere (in the sense of the distribution of air density with altitude) is interesting in that when there is insufficient atmospheric temperature sounding data (when it is impossible to take the corresponding integral) (1, 2), the approximate magnitude and sign of the meteorological effect can be evaluated, without knowledge of which an examination of extra-atmospheric variations in cosmic rays becomes more difficult. In addition, such an examination would help clear up the question of the possibility of applying the observed variations in cosmic ray intensity to meteorological investigations. (3) As an example of such typical cases of change of atmospheric state, we can try to examine various types of air fronts known from meteorology. (4,5)

Until now there has been only one work of this kind. (6)

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The discussion in the present article concerns average variations in the intensity of the hard component of cosmic rays during passage of air fronts of four types and during periods without fronts. In this discussion, as distinguished from the above mentioned work by Loughridge (6), measurements of cosmic ray intensities were made in a stationary post on dry land near sea level; the cases of fronts and periods without fronts were examined on magnetically static days; the diurnal course was excluded from data on the variations of cosmic ray intensity; the discrepancy in the rate of displacement of the fronts was considered; and the periods without fronts were subdivided according to the type of terrestrial pressure variation.

The average hourly global intensity of the hard component of cosmic rays was measured with an accuracy up to several tenths of a percent. In addition, we obtained data from an hourly observation of the terrestrial pressure and the Earth's magnetic field, data of the synoptic situation after every 3 hours, and data from hourly observations (visual) of cloudiness.

The fronts were examined (a) if they were not accompanied by magnetic storms and the variations in the horizontal component of the earth's magnetic field δH did not exceed 100 gamma units for the whole period of examination of the given front: (b) if they could be recognized according to type (determination of synoptics); (c) if they were tropospheric and dynamically significant (in the cases of warm and cold fronts) and passed across the observation point having motion nearly perpendicular to the terrestrial line of the front; (d) if they were not accompanied by repeated outbreaks during the period examined; and (e) if they were sufficiently stable, i.e., did not break up during the entire time of observation (from 1500 km before the observation point up to 400-500 km after passing it), and were tracked on all synoptic maps of intermediate periods.

Altogether 107 individual cases were chosen of the passage of fronts of four types: 32 warm fronts, 48 cold fronts, 14 occlusions of the warm-front type, 13 occlusions of the cold-front type. For each separate case of the passage of fronts the beginning and end of three intervals of time for the location of the observation post were fixed: the first and third in the zone of "pure" air masses (respectively cold and warm in the case of warm fronts, and the reverse for cold fronts), and the second in the zone of the projection of the frontal surface (Figure 1). For fronts of occlusion, two periods were taken corresponding to a distance of 600 km before and 400 km after passing the terrestrial line of the front. The most rigid of these fixations was that of the moments of passage of the terrestrial lines of the front. The upper bounds were recorded, proceeding from data in Khromov (4), Tverskogo (5), and in Bachurin and Turketti (7) and from indirect aerology (character of cloudiness). It was assumed that on the average the upper bound of a warm front exists when its terrestrial line is still at a distance of 800 km before the observation point; and for a cold front, at a distance of 400 km behind its terrestrial line.

The choice of periods without fronts included such periods when (a) judging by synoptic maps there were neither fundamental nor secondary fronts anywhere within 1,000 km of the observation post, and (b) magnetic storms were not observed and the variation in the horizontal component of the earth's magnetic field did not exceed 100 gamma units for the given period.

In the overwhelming majority of cases such periods were regions of anticyclones. These periods were subdivided into two groups according to the type of terrestrial pressure variation: periods of increase (54 individual cases) and periods of decrease (42 cases). The average range of atmospheric pressure variations in the indicated groups (5-6 mb) was greater than a similar range by types of fronts.

In conformity with the indicated choices average curves of variations in the intensity of the hard component were determined separately for each type of front and for periods without fronts, both the observed variation $\delta\bar{I}$ and the variation $\delta\bar{I}_h$ being corrected for barometric effect.

1. For the determination of δI_h a barometric coefficient very close to the one in Loughridge and Gast (6) was used, $K_\delta = 0.14\%$ of I_0 at 1 millibar variation in atmospheric pressure at the observation post (I_0 is the average magnitude of the intensity).

2. The daily course was excluded from the data on δI and δI_h since the diurnal effect in δI and δI_h, being equal to 0.3% of I_0, is comparable to the unknown variation; and, through a supplementary examination, an indication was obtained that the observed diurnal effect of the hard component of intensity near sea level does not depend upon the synoptic situation.

3. In the derivation of the average curves of $\delta\bar{I}$ and $\delta\bar{I}_h$ the average values of the individual curves coincided. Each point of the average curves was determined by averaging the average magnitudes (for a period of 2 to 9 hours depending on the velocity of the front) of the variations in the intensity of cosmic rays δI (δI_h) in individual cases which were observed during intervals of time corresponding to identical positions of the observation post relative to the frontal surface (in the case of fronts) or to the course of the terrestrial pressure (in the case of periods without fronts).

The results of the averaging are presented in Figures 1, 2, and 3. The scale of time shows only the average intervals of time of examination (for the method of averaging the individual cases for the derivation of curves of $\delta\bar{I}$ and $\delta\bar{I}_h$, see above). The mean square errors, shown in Figures 1 and 2, apparently do not express errors in the usual sense, since they also include individual (not random) discrepancies of fronts. In addition, in one case of the passage of a sharply expressed cold front we succeeded in calculating the course of intensity variations δW (Figure 4) predicted by the theory of the meteorological effect.(1, 2) The calculation of δW was carried out taking into account the temperature distribution only up to an altitude with pressure $h = 300$ mb.

From the results obtained it is seen that:

1. The intensity of the hard component of cosmic rays during the passage of fronts tests the characteristic variations. These variations differ with respect to type, in accordance with various types of fronts. Basically, the intensity $\delta\bar{I}_h$ falls during transition from a cold air mass to a warm one. Minimum intensity is observed in the zone of a "pure" warm air mass, and maximum intensity is observed in the zone of a "pure" cold air mass. The effect in $\delta\bar{I}_h$ varies on the average between 0.4 and 0.6% of I_0.

2. Data on the variation $\delta\bar{I}_h$ cannot be explained by errors in the application, for example, of an increased barometric coefficient. This can be seen from a comparison of the variations $\delta\bar{I}_h$ in Figures 1, 2, and 3. The cause of the indicated variations $\delta\bar{I}_h$, apparently is concealed in the corresponding variations in the temperature profile of the atmosphere (Figure 4) as follows from the theory of the meteorological effect on cosmic rays(1, 2) The latter confirms that the meteorological effect is provoked by the total influence of air density variation in all layers below the level of meson generation, and not only by variation in the altitude of generation, as was thought earlier.(6)

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3. The magnitude and course of the variations in cosmic ray intensity in each individual case of fronts of identical type are not strictly definite and coincident, but display considerable fluctuation (Figure 4), which corresponds to a different power and profile of fronts of one and the same type.(4, 7) The existing difference in the course of δW and $\delta \bar{I}_h$ apparently reflect the contribution of the upper layers (higher than the level with h = 300 mb).

4. In contrast with the results of work (6), the variations $\delta \bar{I}_h$ in periods without fronts are not completely smooth, but show a definite tendency (Figure 3). Actually, if for both types of terrestrial pressure fluctuations we determine the variations $\delta \bar{I}_h$ from the general average level of cosmic ray intensity, we get a wave of variations $\delta \bar{I}_h$ which leads the terrestrial pressure $\delta \bar{h}$ wave by about 1/4 of a wavelength. The explanation of this picture, proceeding from theory as outlined in Feynberg and in Dorman (1, 2), must evidently be sought in connection with pressure variations on the earth and at different altitudes, on which there are well known views in meteorology.(4, 8) (See, for example, Shedler's curves.(4))

5. The discovered intensity variations $\delta \bar{I}_h$ (in Loughridge's work (6) they are lacking) connected with the upper bound of fronts (Figure 1), with a point of occlusion (Figure 2), and with regions of increase and decrease of terrestrial pressure (Figure 3), are quite interesting from the point of view of meteorology as well as for the study of variations in cosmic ray intensity.

It follows from the above that:

1. For a dependable exclusion of the meteorological effect in each separate case of the absence of accurate data for the temperature profile of the atmosphere, a further, more detailed classification into types of meteorological processes is desirable.

2 The question of the possibility of using the observed variations in cosmic ray intensity in meteorological investigations requires further clarification. It seems to us that in the presence of aerological data on the average temperature profile of the troposphere in cases of known typical meteorological processes, there exists the possibility of calculating the expected contribution of the troposphere δW_{trop}.(1, 2) Granting that in the indicated cases the observed variations in cosmic ray intensity $\delta \bar{I}_h$ are provoked basically by variations in the temperature profile of the atmosphere, i.e., $\delta \bar{I}_h \approx \delta \bar{W}$, we can find the average expected contribution of layers of the atmosphere lying above the troposphere, $\delta \bar{W}_{high} \approx \delta \bar{I}_h - \delta \bar{W}_{trop}$ for each definite type of meteorological process in the troposphere. Here, $\delta \bar{W}_{high}$ can be used as an objective, although indirect, factor (along with other meteorological data and supplementary to it) for judging the character of the connection of tropospheric processes with processes in the upper layers. As is well known, there are many things unclear in meteorology concerning this particular question (4, 5, et al.)

In conclusion I express my thanks to Prof Ye. L. Feynberg, Yu. G. Shafer and G. A. Tolstobrova for their advice and assistance.

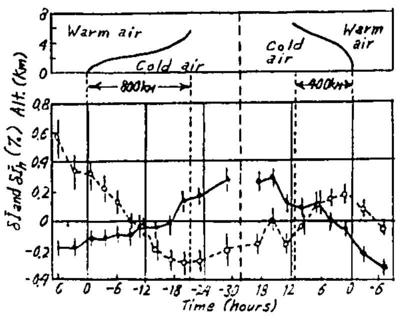

Figure 1. Above, profile of a warm (left) and cold (right) front. Below, average course of the variation in the intensity of cosmic rays observed δ I (white circles) and corrected for barometric effect δ I_h (black circles) during the passage of warm fronts (of 32 cases, on the left) and cold fronts (of 48 cases, on the right)

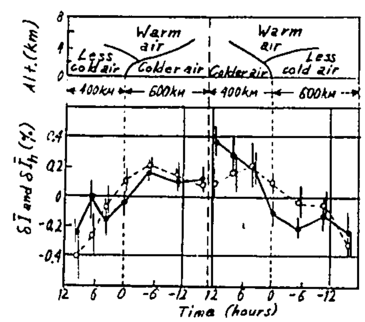

Figure 2. Above, profile of the occlusion of a warm front type (left) and the occlusion of a cold front type (right). Below, average course of the variation in the intensity of observed $\delta \bar{I}$ (white circles) and corrected for barometric effect $\delta \bar{I}_h$ (black circles) during the passage of an occlusion of a warm front type (of 14 cases, on the left) and an occlusion of a cold front type (of 13 cases, on the right)

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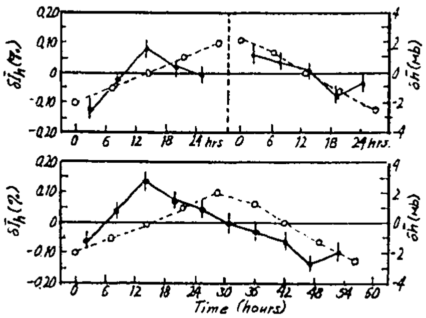

Figure 3. Average course of fluctuations of terrestrial pressure $\delta \bar{h}$ and intensity of cosmic rays $\delta \bar{I}_h$ in periods without fronts. Above: δI_h during increase (left, of 54 cases) and during decrease (right, 42 cases) of terrestrial pressure $\delta \bar{h}$. Below: course of $\delta \bar{I}_h$ for the same cases, when $\delta \bar{I}_h$ is evaluated from the average level of intensity of cosmic rays common to both types of variations

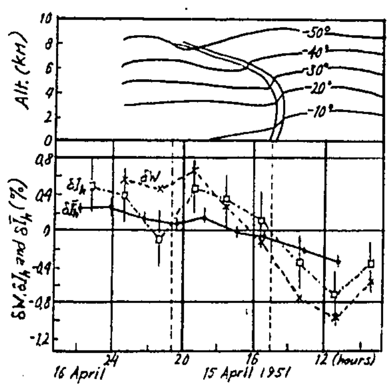

Figure 4. Variation in the intensity of cosmic rays during the passage of a powerful cold front (15 April 1951). Below: δI_h is the observed variation in the intensity of cosmic rays after introducing barometric corrections; δW is expected variation of cosmic rays (1,2), integral taken between the limits of a 300 mb pressure level and a 1,000 mb pressure level; $\delta \bar{I}_h$ is average variation of cosmic rays during the passage of cold fronts (presented for comparison). Above: temperature profile of the atmosphere and profile of a front ($T^{o}C$)

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CONTRIBUTION OF METEOROLOGICAL VARIATIONS OF WINTER ATMOSPHERE TO DIURNAL EFFECT OF VARIATIONS IN COSMIC RAY INTENSITY

A. I. Kuz'min

In the investigation of the diurnal effect as well as in the study of the nature of other regular and irregular variations in cosmic ray intensity, it is important to single out variations connected with meteorological variations in the winter atmosphere.

The question of the contribution of diurnal fluctuations of meteorological factors to the diurnal effect of variations in cosmic ray intensity has been considered in works by Duperier (1), Dolbear and Elliot (2), Hogg (3), however in all of these works the effect of the redistribution of masses in the atmosphere (4) was not taken into account; this is just as essential as the effects of simple meson absorption, on account of the growth of an air mass over the apparatus and the displacement of the meson generation level during fluctuations of atmospheric temperature. Besides, the so-called positive temperature effect (5) was incorrectly considered in Dolbear and Elliot.(2)

In this article we shall present data on the measurements of the global intensity of the hard component of cosmic rays δI, obtained with great accuracy (up to several tenths of a percent for one hour of observations), at an altitude of 100 meters above sea level. The measurements were carried out according to a theoretical scheme proposed by Feynberg (4) and generalized by Dorman (5) to a two-meson scheme which takes into account the generation of μ-mesons over the whole width of the atmosphere through the disintegration of π-mesons generated by the initial component.

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The figure shows the diurnal course of the intensity of the hard component of cosmic rays δI_h, corrected for fluctuation of barometric pressure h (the barometric coefficient k = -0.14% at 1 mb), obtained by averaging data of continuous measurements for the period July 1949-May 1952. The heavy line shows the first harmonic. The experimental points (crosses) are placed around it. The same figure has circles to show two points (A, B) for δN, precalculated from the averaged meteorological data (the theoretically expected intensity of the hard component of cosmic rays taking into account the meteorological effect. To calculate these points we used meteorological data from radio soundings of the atmosphere only for those days when the altitude of the radio sounding apparatus for both periods was not less than 12 km. Such a choice helped to exclude errors in the calculations due to an unequal distribution of successful ascents during the diurnal and nocturnal periods over the course of a year. A total of 72 twin flights were used: 17 in winter, 20 in summer, 14 in spring, and 21 in the fall.

The results of the calculation of the meteorological "day-night" effect δN together with the observed deviations of the intensity of the hard component of cosmic rays (in which the fluctuations of barometric pressure are already accounted for) δI_h are given in Table 1.

Table 1

	δN (%)	δI_h (%)
Winter	-0.08±0.02	0.34±0.09
Spring	-0.40±0.03	0.46±0.1
Summer	-0.83±0.02	0.14±0.08
Autumn	-0.73±0.02	0.28±0.08
Average	-0.35±0.01	0.21±0.05

From the appended figure and the table the following can be observed: first of all, the precalculated "day-night" effect δN and the observed deviation δI_h are opposite in phase despite the results in Dolbear and Elliot(2), and, secondly, introducing a correction into the meteorological effect approximately doubles the "day-night" effect in the intensity of the hard component of cosmic rays. The absolute magnitudes of the results of the calculations, shown in Table 1, can only be increased at the expense of a systematic error in the measurement of the temperature of the atmosphere due to the influence of solar radiation on the temperature receiver of the radio sounding apparatus.(6) The contribution from this source of systematic error at high latitudes must be significant only in the summertime when the sun has a maximum altitude over the horizon. On the other hand, it is known(6) that the temperature increase at north latitude 60-62° reaches 2° C at an altitude of 13 km. From this it can be shown by the law of the exponential decrease of the mass of an atmospheric substance with altitude that the radiation error at an altitude of 6 km cannot materially exceed tenths of a degree, and that at the level of our meteorological observations it reaches hundredths of a degree. For this reason the absolute magnitude of the expected meteorological "day-night" effect in the summer season cannot be increased materially more than 0.2% Thus the meteorological "day-night" effect is opposite to the observed effect and has a magnitude of the order of 0.4%. The correctness of such a conclusion is confirmed also by the fact that the average altitude at which the pressure is equal to 300 mb, obtained from 3 years' radio sounding data, is higher during the day than at night. This follows from Table 2.

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Table 2

	Winter (meters)	Spring (meters)	Summer (meters)	Autumn (meters)
Average "day-night" difference in altitude at pressure = 300 mb	46	38	37	30

In addition, it can be seen from Table 2 that the positive "day-night" difference of the altitude of the level at which the pressure equals 300 mb changes little from season to season. A comparison of Tables 1 and 2 shows the significant role of the redistribution of masses of the atmosphere below the level with a pressure of 300 mb in the variation of the diurnal effect from season to season.

In order to evaluate the complete contribution of the meteorological fluctuations of the winter atmosphere to the diurnal effect of cosmic rays, a continuous round-the-clock sounding of the atmosphere is needed, more often than is being done now by meteorologists. Nevertheless, from Selezneva's detailed analysis (7) of many years' aerological observations in Slutsko, it is known that the diurnal course of the temperature above 3 km possesses an independent character and grows with altitude. The fundamental maximum in the course of the temperature is observed at 1300-1400 hours local mean solar time. Therefore, assuming that the maximum temperature on the average for the whole troposphere is reached at 1400 hours, we can suppose that the indicated results of the calculation of the meteorological "day-night" effect reflect only about 70% of this effect, since these results refer to times 3 hours away from the experimental values of the temperature. Consequently, the magnitude of the possible meteorological effect must be on the average about 0.6% (the assumed diurnal course of the meteorological effect δN is shown in the figure by a dotted line). Using the observed diurnal course $\delta \bar{I}_h$, we find that the diurnal effect of variations in the intensity of the hard component of cosmic rays has a nonmeteorological origin and is characterized by a magnitude of the order of 1 % (in the figure the curve is shown by the line made up of dots and dashes).

In this regard we may note that the variation in the diurnal fluctuations of meteorological factors with respect to seasons of the year can explain the seasonal variation of the diurnal effect of cosmic rays. It is known (7) that the greatest diurnal fluctuations of the temperature of the troposphere take place in the summer, and the smallest in winter.

Thus, if the diurnal course of the meteorological effect of the intensity of cosmic rays is opposite to the observed course, it follows that we might expect that the observed diurnal effect in the intensity of cosmic rays will be least in summer and greatest in winter. This is actually the case as can be seen from Table 3, in which are indicated the parameters of the first harmonic, calculated from the seasonal averages of the diurnal course of the intensity of the hard component of cosmic rays $\delta \bar{I}_h$.

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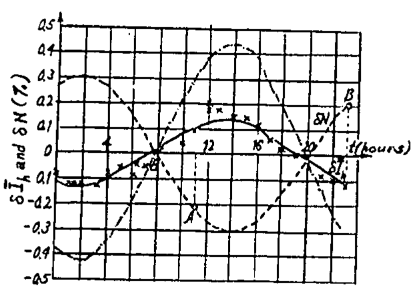
Table 3

	Amplitude (%)	Time of Maximum (hrs)
Winter	0.18±0.004	13.9
Spring	0.15±0.004	13.9
Summer	0.09±0.004	13.4
Autumn	0.12±0.005	13.3
Over many years	0.13±0.002	13.4

From this table it can be seen that the diurnal effect observed in summer is half as great as that of winter, and this agrees with the increase of the meteorological diurnal effect (Table 1). However, the data indicated in Table 3 contradicts the works of Duperier (1), who, recording the entire intensity of cosmic rays by the method of coincidences, discovered an increase in the effect in the summer months and a decrease in winter. The contradiction is apparently explained by the fact that in Duperier's measurements the contribution of the diurnal fluctuations of meteorological factors to the diurnal effect of cosmic rays was considerably greater than in ours, since on the average "softer" particles were observed. Therefore, the seasonal variations of the magnitude of the diurnal effect observed by Duperier (1) are possibly a direct reflection of the variation of the meteorological part of the diurnal effect of cosmic rays.

In conclusion the author thanks Prof Ye. L. Feynberg and Yu. G. Shafer for their comments and advice. The author also thanks Prof G. V. Skripin for helping with the calculations and measurements.



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